2PRTS

09/194286

300 Rec'd PCT/PTO 23 NOV 1998

~~Description~~

Ins a1

Method for optimization of the utilization of connecting sections in systems in which information is transmitted in data packets.

~~The invention relates to a method as claimed in the precharacterizing clause of patent claim 1.~~

In modern packet switching systems, information is transmitted in data packets. One example of this is ATM cells. These have a header part and an information part. The header part is used to store connection information, and the information part is used to store the wanted data to be transmitted. As a rule, the actual transmission takes place via connecting sections between the transmitter and receiver. In this case, there may be a requirement to utilize the connecting sections in such a manner that a plurality of transmitting devices transmit the cell streams originating from these devices via the same connecting section.

In order to allow the transmission of the respective cell streams to be carried out in accordance with the requirements of the individual cell streams, a so-called WEIGHTED FAIR QUEUEING SCHEDULING method has become generally accepted in the prior art. The corresponding relationships are described, for example, in the document "Virtual Spacing for Flexible Traffic Control", J.W. Roberts, International Journal of Communication Systems, Vol. 7, 307-318 (1994). In this case, the individual cell streams are assigned different weighting factors, which are used to control the actual transmission process on the individual connecting sections. Reference should be made to Figure 3 to assist understanding.

By way of example, ~~this~~ Fig 3 shows cell streams 1 ... n. The n cell streams are passed from a transmitting device DEMUX in the direction of one or more receivers. In practice, only one common connecting section is used in this case. The n cell streams are furthermore assigned weighting factors r_1 ... r_n. To assist understanding, it is assumed that it is intended to pass only two cell streams, namely the cell streams 1, 2, via a connecting section. The connecting section is furthermore intended to have a maximum transmission capacity of 150 Mbit/s. The two cell streams 1 and 2 are assigned weightings $r_1 = 2$ and $r_2 = 1$. This results in the cell stream 1 being transmitted at a transmission rate of 100 Mbit/s, and the cell stream 2 at only 50 Mbit/s, if cells for both cell streams are present for transmission. If only one of the two cell streams has cells to transmit, this cell stream is assigned the total transmission capacity of 150 Mbit/s.

Figure 2 shows how the theoretical considerations addressed above are implemented in practice in the prior art. This shows how data packets, or ATM cells, are dealt with using the weighted fair queueing scheduling algorithm. In this case, incoming cells are supplied to the input device EE, are passed on to the demultiplexing device DEMUX and are stored there with the aid of a demultiplexing function, which is implemented here, and with the assistance of an identifier QID in a logic queue. The identifier QID is, in this case, contained in the cell header of each cell.

At the same time, control data which are determined in the input device EE are ~~for this purpose~~ supplied to a scheduler device S. A scheduling algorithm which is known, ~~per se~~ is executed in this device.

This may be, for example, the weighted fair queueing scheduling algorithm or any other algorithm. This algorithm determines, for example, the sequence in which, or the time at which, it is intended to read the cells which are stored in the buffer stores P1...Pn. The result of the assessment of the control data by this algorithm is supplied to the output device AE. The cells stored in the buffer stores P1...Pn are now read, on the basis of the result of the assessment, by the algorithm which is being executed in the scheduling device S. Furthermore, an acknowledgement signal is fed back to the input device EE. After this, and when a new cell with an identifier QID arrives in the input device EE and when an acknowledgement 'selected QID' is present, the input device EE uses the buffer filling level for QID = i as well as the scheduling method to decide whether the message "SCHEDULE QID" is generated. This message indicates to the scheduler device S that it should carry out initial planning for the next transmission time for this identifier QID, in some way.

A problematic feature of such a procedure is that, although the weighted fair queueing scheduling algorithm guarantees minimum cell rates, a maximum cell rate limiting cannot be carried out here. However, this is a major factor since, in practice, both minimum and maximum cell rates often have to be complied with; for example, in the case of ABR (available bit rate) traffic.

Ins a2

The present invention is therefore directed toward ~~based on the object of~~ indicating a way in which the weighted fair queueing scheduling algorithm can be modified in such a way that optimized transmission is ensured ~~here~~ as well.

a3

~~The object is achieved on the basis of the features specified in the precharacterizing clause of patent claim 1, by means of the features in the characterizing part.~~

An advantageous feature of the present invention is that a two-stage scheduling method may be carried out depending on an identifier which is contained in the packet header. In this case, the result of the first stage is used as an input signal for the second stage. This results, in particular, in the capability to control both a lower limit and an upper limit of the cell rate. ~~In particular, this~~ This method is not, however, limited to the use of a specific algorithm.

Ins a47

Further refinements of the invention are provided in the dependent claims.

~~Claim 2 provides that~~ In an embodiment the connection parameters are limited during the transmission process, by means of the first stage of the two-stage scheduling method. This is intended, in particular, to control limiting of the cell rate. This results in the cells not being transmitted at higher cell rates during the transmission process.

~~Claim 3 provides that~~ In an embodiment the second stage of the two-stage scheduling method is the weighted fair queueing scheduling algorithm. This is linked to the advantage that a proven method can be used. A further advantage of this is that this algorithm guarantees lower limiting of the cell rate.

~~Claim 4 provides for~~ In an embodiment an input device is provided to contain a table which ~~contains~~ includes the current filling levels of the buffer stores. This is linked to the advantage that a current map of these filling levels is stored here at all times.

In an embodiment ~~Claim 5 provides that~~, depending on the control data obtained from the scheduler device, the output device takes cells from at least one of the buffer stores and acknowledges this process to the input device. As a result of the feedback, the reading process has a direct influence on the first stage of the two-stage method. The two stages of the two-stage scheduling method thus do not operate independently of one another. The way in which the first stage operates is influenced by the way in which the second stage operates. The identifier or the packet length may be used, for example, as feedback parameters.

In an embodiment ~~Claim 6 provides that~~ the identifier is entered while the connection is being set up.

In an embodiment ~~Claim 7 provides that~~ the data packets are ATM cells. The present invention can ~~thus~~ invention be applied in particular to ATM networks.

Ins a5

In ~~the~~ figures:

Figure 1 shows a schematic representation of the method according to the present invention;

Figure 2 shows a schematic representation of the practical application of the prior art;

Figure 3 shows a schematic representation of theoretical considerations relating to the prior art.

Ins a6

Figure 1 shows a schematic representation of the method according to the present invention. In this case, it is assumed that the information is transmitted in ATM cells, using an asynchronous transfer method (ATM).

The cells are supplied to the input device EE in a cell stream. The routing information is stored in the header part of each cell. Furthermore, an identifier QID is ~~has been~~ stored here while the connection is being set up. This identifier is a cell stream identifier which is entered in the cell header on a connection-specific basis or for a group of connections. As a rule, the identifier QID is assigned simple numerical values. In the present exemplary embodiment, the identifier QID is intended to have the values 1...N. Originating from the input device EE, the cells themselves are supplied to the demultiplexing device DEMUX where they are written into buffer stores P1...Pn, and designed as a logic queue~~,~~ with the aid of a demultiplexing function, which is implemented here, and with the assistance of the identifier QID.

The input device EE furthermore contains a table T as to which of the connections require the connection parameters to be limited during the transmission process. In the present exemplary embodiment, it is assumed that limiting of the cell rate is controlled in the sense of limiting the connection parameters. In order to verify the connection, the identifier QID is taken from each of the incoming cells and is compared with the entries in the table T.

If it is not intended to limit the cell rate for a connection, corresponding control data are supplied via the connecting section B to the scheduler device S_2, bypassing the scheduler device S_1. There, the control data are used in a scheduling algorithm which is known per se. In the present exemplary embodiment, this is intended to be weighted fair queueing scheduling method, which has already been described in the introduction. Such an algorithm results in a lower cell rate being guaranteed, in the sense of guaranteeing the connection parameters of the cells during the transmission process.

According to the present exemplary embodiment, the cell rate for one of the connections is limited, for example, for the connection with the number 8 (QID=8). In this case, the control data are supplied via the connecting section A to the scheduler device S_1. Here, an algorithm starts to be executed, which controls an upper limit on the cell rate. This is done by a function implemented here using the identifier QID for initial planning of the control data supplied from the input device EE, such that the individual cells do not exceed a predetermined rate. At the time at which the scheduler device S_1 would read a cell, however it produces ~~however,~~ a control signal itself for initial planning of the read time which correspond~~ing~~s to the general scheduling algorithm being executed in the scheduler device S_2. No initial planning of the next event takes place in the scheduler device S_1 for the same identifier QID. Thus, stimulated by the scheduler device S_1, the scheduler device S_2 plans the sequence for the indicated identifier QID, corresponding to the scheduling algorithm being executed here. The cells initially planned by the scheduler device S_1 may thus experience an additional delay. The peak bit rate set in the scheduler device S_1 thus may ~~thus~~ be different from that used to read the cells.

moved

By way of example, the weighted fair queueing scheduling algorithm is intended to be used in the scheduler device S_2 in the present exemplary embodiment, although other algorithms can also be used. The method according to the present invention is not limited to the use of a specific algorithm.

The result of the evaluation of the algorithm being executed in the scheduler device S_2 is passed to the output device AE.

Whenever it is intended to read the next cell from a buffer store P1...Pn with a specific identifier QID, this is indicated to the output device AE. This reads the first cell with the indicated identifier QID from the buffer store P1...Pn in question, and reports this together with the corresponding identifier QID to the input device EE. The latter then checks whether a further cell with this QID is stored in the buffer store. If this is the case, a corresponding signal (SCHEDULE QID) is sent to the scheduler device S_1. If this is not the case, no further action takes place in the sense of initial planning (reading) in the scheduler device S_1 for this identifier QID.

Pursuant to this method ~~This method means that~~ an event for an identifier QID can be initially planned only in the scheduler device S_1 or S_2, but not at the same time in both devices. Furthermore, the two function blocks S_1 and S_2 are not linked to a specific implementation. This two-stage algorithm is thus used to determine the sequence in which, and the time at which, it is intended to read the cells which are stored in the buffer stores P1...Pn.

Finally, it should also be mentioned that the above exemplary embodiment has been described using the example of ATM cells. However, the present invention is not just limited to this. The method according to the present invention likewise can ~~likewise~~ be used for the transmission of information in data packets as such. However, in this case, it is necessary to ensure that the packet length is added to the control data.

Ins a4)